Black Lake Grocery Groundwater Monitoring Results, October 2021: Data Summary Report

Environmental Assessment Program
Publication 23-03-023
Authored by Jacob Carnes
May 2023

Abstract

Black Lake Grocery is an active gas station and convenience store located on the northwest shore of Black Lake in Thurston County, Washington. In 1989, petroleum hydrocarbon contamination was discovered in soil and groundwater beneath the site. The source of the contamination was Black Lake Grocery's underground storage tanks. In 1995, these tanks and a large amount of contaminated soil were removed. In 2004, a treatment wall consisting of a trench filled with a permeable reactive material was installed along Black Lake's shoreline. The treatment wall was installed to passively treat contaminated groundwater flowing toward the lake.

From November 1993 through June 2009, Summit Envirosolutions conducted groundwater sampling of on-site monitoring wells to monitor petroleum contamination. In 2011, the Washington State Department of Ecology (Ecology) resumed sampling to characterize the groundwater contaminant concentrations.

This report describes the water quality results for groundwater samples collected during October 2021 from 5 monitoring wells. The samples were analyzed for benzene, toluene, ethylbenzene, xylene (BTEX), and total petroleum hydrocarbons as gasoline (TPH-G).

Water quality results for groundwater sampling in 2021 continue to confirm that the near-surface aquifer at Black Lake Grocery is contaminated across the site. Since 1995, contaminant concentrations have decreased but continue to exceed (not meet) established cleanup levels in 4 of the sampled wells. BTEX and TPH-G concentrations decreased significantly after passing through the treatment wall, but the continued presence of high contaminant concentrations in wells on the downgradient side of the wall and near the shoreline suggests that petroleum products from the site are likely migrating to Black Lake.

Publication Information

This report is available on the Department of Ecology's website at:
https://apps.ecology.wa.gov/publications/summarypages/2303023.html

Data for this project are available in Ecology's EIM Database. Study ID: PMART007

The Activity Tracker Code for this study is 12-001.

Suggested Citation:
Carnes, J., 2023. Black Lake Grocery Groundwater Monitoring Results, October 2021: Data Summary Report. Publication 23-03-023. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/summarypages/2303023.html

Water Resource Inventory Area (WRIA) and 8-digit Hydrologic Unit Code (HUC) numbers for the study area:

- WRIA: 23
- HUC number: 17100103

Contact Information

Publications Team
Environmental Assessment Program
Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600
Phone: 360-407-6764

Washington State Department of Ecology – https://ecology.wa.gov

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Shoreline 206-594-0000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Union Gap 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

This report was prepared under the supervision of a licensed hydrogeologist. A signed and stamped copy of the report is available upon request.

Background

Black Lake Grocery is an active gas station and convenience store on the northwest shore of Black Lake (Figure 1). The store is on a 5.2-acre parcel of land about 100 feet from the lakeshore. In 1989, gasoline-range petroleum hydrocarbons contamination of soil and groundwater beneath the store was discovered during a geotechnical study for a planned expansion of Black Lake Boulevard (Dames and Moore, 1990).

In 1995, cleanup activities began during the expansion of Black Lake Boulevard. In June and July 1995, 7 underground storage tanks and 1,200 cubic yards of petroleum-contaminated soils were removed from the site as an interim action. The excavated area encompassed the area between the grocery store and the property boundaries at Goldsby Road and Black Lake Boulevard (Figure 1). The depth of the soil excavation ranged from about 10 to 13 feet below ground surface (bgs).

Soil samples from the edge of the excavated area continued to exceed (not meet) the Model Toxics Control Act (MTCA) Method A cleanup levels in soils (WAC 173-340-740) for benzene, toluene, ethylbenzene, and xylenes (BTEX) as well as total petroleum hydrocarbons as gasoline (TPH-G). The contaminated soil beyond the excavated area could not be removed because the soil was beneath the adjacent county roads (Summit, 2000).

Summit (2000) completed a remedial investigation/feasibility study (RI/FS) of the Black Lake Grocery site. In the RI/FS the contaminant plume was defined as extending from the former location of the underground storage tanks downgradient to Black Lake. The northeastern edge of the plume was shown to coincide with the location of a stormwater culvert under Black Lake Boulevard. In 1995, a groundwater sample collected from north of the culvert did not contain petroleum contamination (Summit, 2000). Since 1995, no additional sampling has occurred northeast of the mapped plume extent.

To remediate the remaining petroleum hydrocarbon contamination in soils and groundwater, the remediation strategy selected in the Cleanup Action Plan (CAP) (Ecology, 2002) relies on natural attenuation and a passive treatment wall installed along the lake shoreline.

In November 2004, the treatment wall was constructed along the shore of Black Lake. The wall is about 120 feet long, 5 feet wide, and 12 feet deep. The permeable reactive material within the wall is an engineered sphagnum peat moss. The permeable reactive material was designed to absorb petroleum hydrocarbons and to provide a catalytic surface on which microbial activity can occur. Upgradient of the treatment wall, natural attenuation mechanisms are relied upon to mitigate the groundwater contamination.

Site cleanup will be achieved when contaminant concentrations throughout the Black Lake Grocery site (point of compliance) have met the MTCA method A groundwater cleanup levels (WAC 173-340-720) and CAP cleanup levels (Ecology, 2002). The cleanup levels for toluene, ethylbenzene, and xylenes established in the CAP are more stringent than the MTCA method A groundwater cleanup levels. However, the CAP cleanup levels are cited as MTCA method A cleanup levels (Ecology, 2002).

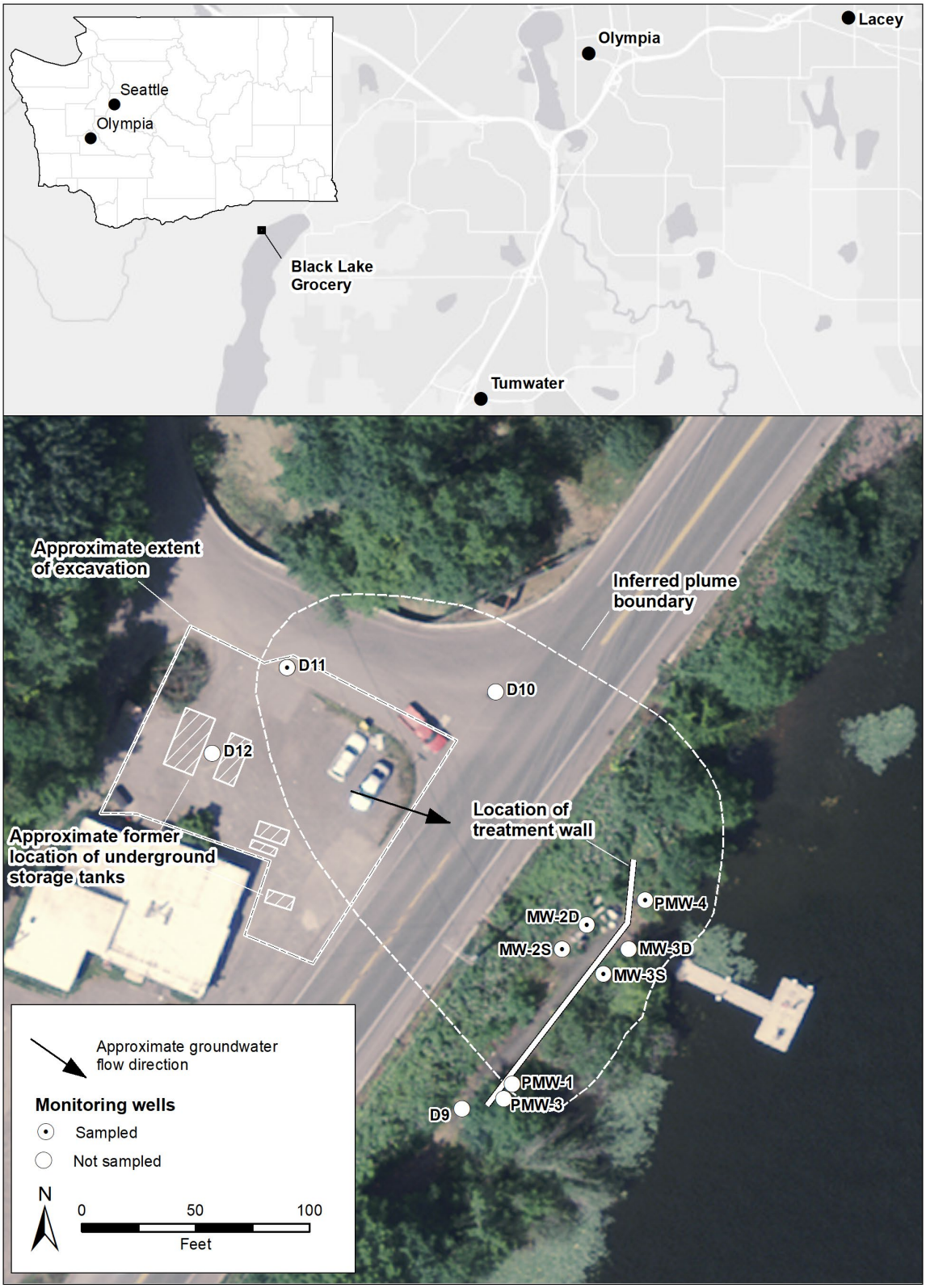

Figure 1. Black Lake Grocery Location and Site Details.

From November 1993 through June 2009, Summit Envirosolutions sampled and analyzed groundwater for petroleum products at the site. Concentrations of BTEX and TPH-G in groundwater decreased after the excavation of contaminated soils and installation of the treatment wall. However, contaminant concentrations still exceeded the MTCA groundwater cleanup levels (WAC 173-340-720) in 5 of the 11 monitoring wells (Appendix Figures A1-A4, Tables A1-A7). In August 2011, Ecology resumed groundwater sampling because of the continued elevated concentrations of petroleum products in groundwater (Marti, 2013).

Summit (2005) estimated that contaminant concentrations would fall below cleanup levels within 10 to 25 years, due to the combined effects of excavation of source material and biodegradation. In 2011 and 2012, Ecology conducted sampling to measure conventional parameters (dissolved organic carbon, total and dissolved iron, sulfate, nitrate, nitrite, and turbidity) in groundwater. The purpose of that sampling was to evaluate the potential for natural attenuation of the site. The results of this sampling indicate conditions favorable for the biodegradation of petroleum hydrocarbon contamination (Marti, 2013).

This data report summarizes groundwater results from select on-site wells for October 2021. The data and associated monitoring reports for this project are available at Ecology's Environmental Information Management (EIM) website www.ecy.wa.gov/eim/index.htm. Search Study ID, PMART007.

Methods and Results

In October 2021, Ecology collected groundwater samples from 5 monitoring wells (D11, MW-2S, MW-2D, MW-3S, PMW-4) at the Black Lake Grocery site (Figure 1). Four of the selected wells are known to have contaminant concentrations that exceed the site cleanup levels. Well D10 historically has had high petroleum concentrations (see Table A2), but was not sampled because it is difficult to access due to traffic. Also, D10 is low yielding and the water level in the well is slow to recover.

Ecology employed industry-standard, low-flow sampling techniques. Because most of the wells are low yielding and slow to recover, each well was purged and sampled using a peristaltic pump with dedicated tubing. Prior to sampling, the wells were purged through a continuous flow cell at a rate of 0.5-liter/minute or less. The wells were purged until field parameters (pH, temperature, specific conductance, dissolved oxygen, and oxidation reduction potential) stabilized as specified in SOP EAP078 (Marti, 2020). Well construction information and water levels are shown in Table 1. Stabilized field measurements are presented in Table 2.

Table 1. Well construction details and water levels for October 2021.

Well	Land Surface Elevation (feet, NAVD88)	Well Depth (feet bgs)	Screened Interval (feet bgs)	2021 Groundwater Elevation (feet, NAVD88)
D-11	136.08	15	5 – 15	129.18
MW-2D	132.77	15	12 – 15	128.89
MW-2S	131.97	5	2 – 5	127.66
MW-3S	131.11	5	2 – 5	127.66
PMW-4	132.14	11	1 – 11	129.54

bgs: Below ground surface.

In October 2021, the water level in well MW-2S rapidly dropped during purging. The well was left to recharge for 4 hours, then sampled without additional purging. The field parameter measurements and analytical results from MW-2S are qualified as estimates.

Table 2. Field measurements from October 2021 sampling.

Well	pH (std. units)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Oxidation-Reduction Potential (mV)	Turbidity (NTU)
D-11	6.3	545	0	-85	1.6
MW-2D	6.7	289	1.1	-21	4.4
MW-2S	6.2 EST	652 EST	1 EST	-23 EST	28.8 EST
MW-3S	5.9	441	1.4 EST	-65	6.8
PMW-4	6.4	411	0	-135	1.1

EST: Measurement value reported is an estimate.

Groundwater samples collected in October 2021 were submitted for analysis of BTEX and TPH-G to determine petroleum contaminant concentrations upgradient and downgradient of the treatment wall. Analytical results for BTEX and TPH-G are summarized in Table 3. The CAP cleanup levels for the site (Ecology, 2002) and the MTCA Method A groundwater cleanup levels are also listed for comparison (WAC 173-340-720).

A blind field duplicate was collected from well PMW-4. The relative percent difference (RPD) for all analyte duplicate results ranged from 17% to 57% (Table 4). For analytes with RPDs higher than 30% (benzene, toluene, and ethylbenzene), the average of the duplicate results are reported and qualified as an estimate.

Table 3. Analytical results from the October 2021 sampling and associated cleanup levels. All concentrations are in µg/L.

Well	Benzene	Toluene	Ethylbenzene	m,p-Xylene	o-Xylene	TPH-G
D-11	**663**	**92**	**1000**	**247**	**8.72**	**10200**
MW-2D	1U	1U	1U	2U	1U	70U
MW-2S	**1990J**	**551J**	**356J**	**4490J**	**2790J**	**71100J**
MW-3S	**38.2**	**2.3**	**1.73**	**135**	**2.4**	**984**
PMW-4	**21.4J**	**3.76J**	**46.1J**	**91.1**	**5.94**	**2340**
CAP cleanup levels	*5*	*40*	*30*	*20 [a]*	*20 [a]*	*1000*
MTCA cleanup levels	*5*	*1000*	*700*	*1000 [a]*	*1000 [a]*	*800 - 1000 [b]*

Bold: Analyte was detected.
Underline: Values are greater than the CAP and/or MTCA Method A cleanup levels.
U: Analyte was not detected at or above the reported value.
J: The reported result is an estimate.
CAP: Cleanup Action Plan (Ecology, 2002).
MTCA: MTCA Method A Groundwater Cleanup Level (WAC 173-340-720).
[a] The cleanup limit shown for m,p-xylene and o-xylene is for total xylenes.
[b] The MTCA Method A cleanup limit for TPH-G is 800 µg/L when benzene is present, and 1000 µg/L when benzene is not present.

Table 4. Relative percent differences of duplicate results from well PMW-4.

Analyte	PMW-4 (µg/L)	PMW-4 duplicate (µg/L)	RPD (%)
Gasoline	2340	1870	22.3
Benzene	26.7	16.1	49.5
Toluene	4.84	2.68	57.4
Ethylbenzene	76.9	48.1	46.1
m, p-Xylene	91.1	76.6	17.3
o-Xylene	5.94	4.53	26.9

Benzene, toluene, and ethylbenzene failed to meet the data quality objective (DQO) for duplicate sample RPDs of 30% established in the Quality Assurance Project Plan (Marti, 2011). Results presented for benzene, toluene, and ethylbenzene in well PMW-4 are the mean value of the duplicate sample results and are qualified as estimates. The laboratory data quality control and quality assurance results indicate that the analytical performance was good. All results are usable as reported.

Project data collected since 1993 are presented in Figures A1-A4 and Tables A1-A11.

Upper Portion of the Project Area – Well D11

Well D11 is located on the north-central edge of the excavated area. Concentrations of BTEX and TPH-G in well D11 continue to far exceed (not meet) the most stringent cleanup levels (Ecology, 2002; WAC 173-340-740) (Table 3). Concentrations of ethylbenzene in well D11 are close to concentrations measured in the mid- to late-1990s. All other contaminant concentrations have decreased since 1995 (Figure A1), but well D11 continues to have some of the highest BTEX and TPH-G concentrations in the Black Lake Grocery project area.

In October 2021, all contaminant concentrations, except m,p-xylene, increased compared to the June 2020 concentrations (Figure A1, Table A3).

Groundwater Upgradient of the Treatment Wall – Wells MW-2S, MW-2D

Wells MW-2S and MW-2D are part of a cluster of wells located at the base of the bluff, about 100 feet downgradient of the former underground storage tanks. Well MW-2S is relatively shallow, with a total depth of about 5 feet below ground surface (bgs). Well MW-2D has a total depth of about 15 feet bgs.

Of all the wells sampled in 2021, MW-2S had the highest concentrations of petroleum-related contaminants. BTEX and TPH-G far exceeded CAP cleanup levels, and the concentrations of benzene, total xylenes, and TPH-G exceeded MTCA Method A cleanup levels (Ecology, 2002; WAC-173-340-720). The October 2021 concentrations of BTEX and TPH-G decreased compared to June 2020 (Figure A2, Table A8).

None of the contaminants assessed were detected in the 2021 samples from deep well MW-2D. Measured contaminants were last detected in this well in 2013. BTEX concentrations decreased substantially in MW-2D following the interim action (Table A9).

Groundwater Downgradient of the Treatment Wall – Wells MW-3S, PMW-4

Well MW-3S is located on the downgradient side of the treatment wall, about 20 feet southeast of well MW-2S. MW-3S is completed about 5 feet bgs.

Concentrations of BTEX and TPH-G in MW-3S are significantly lower than in MW-2S. However, concentrations of benzene, xylenes, and TPH-G in MW-3S continued to exceed the CAP cleanup levels (Ecology, 2002) in 2021 (Table 3).

In December 1996, BTEX concentrations in well MW-3S (Figure A3) were similar to concentrations in well MW-2S. In February 2005, 6 months after the treatment wall was installed, concentrations in MW-3S had decreased up to 99%. Concentrations then steadily increased, before leveling off in 2011. Since 2014, contaminant concentrations have generally decreased (Figure A3, Table A10).

Well PMW-4 is located downgradient of the north end of the treatment wall. This well is completed about 10 feet bgs. During 2021, petroleum contaminants continued to exceed the cleanup levels established for this site (Table 3). Concentrations of all measured contaminants except benzene increased compared to June 2020 (Table A7). Since monitoring began in 2005, BTEX concentrations have generally decreased (Figure A4). However, TPH-G concentrations in PMW-4 have shown greater fluctuation and remain well above the established cleanup level.

Conclusions

Water quality results from the October 2021 groundwater sampling continue to confirm that the near-surface aquifer at Black Lake Grocery is contaminated with gasoline-range petroleum hydrocarbons. Contamination is present at concentrations higher than (not meeting) applicable cleanup limits in 4 of the 5 wells, both upgradient and downgradient of the treatment wall.

Contaminant concentrations have decreased since excavation and removal of contaminated soils in 1995 and installation of the treatment wall in 2004. In 2015, contaminant concentrations in wells MW-2S and MW-3S began to show pronounced seasonal variation that appears to coincide with changes in groundwater levels. During the fall, when water levels are low, TPH-G and BTEX concentrations in groundwater are relatively low. In the spring and summer, when water levels are higher, contaminant concentrations are relatively high. This apparent trend continued through the 2021 sampling (Figures A2 and A3). This seasonal trend does not appear to be as strong in wells D11 or PMW-4 (Figures A1 and A4).

Comparison of data from well MW-2S to wells MW-3S and PMW-4 shows that contaminant concentrations decrease by at least an order of magnitude on the downgradient side of the treatment wall. This decrease suggests that the treatment wall is actively removing contaminants from groundwater. Yet, contaminant concentrations in MW-3S and PMW-4 still consistently exceed (not meet) the established cleanup levels for this site. The material within the treatment wall has a limited capacity to adsorb and react with contaminants.

BTEX and TPH-G were not detected in near-shore sediment or water samples collected by Ecology (Coots, 2005). However, the continued presence of petroleum contamination in wells MW-3S and PMW-4, which are less than 10 feet from the lakeshore**,** suggests the contaminant plume likely extends to Black Lake.

Recommendations

Based on the October 2021 monitoring results, the following recommendations are provided:

- Because contaminant concentrations continue to exceed (not meet) established cleanup levels, routine groundwater monitoring at the Black Lake Grocery site should continue with the current 18-month schedule. This monitoring will also provide information on the continued effectiveness of the treatment wall. A rise in contaminant concentrations downgradient of the treatment wall may indicate that the sorptive or reactive capacity of the treatment material has been exhausted.
- Consider actions to better characterize current site conditions, including the ongoing effectiveness of the treatment wall and the northern extent of the plume. Sampling for conventional parameters at the Black Lake Grocery site, similar to a previous Ecology study (Marti, 2013), will help assess the current effectiveness of the treatment wall. Collecting samples from temporary piezometers or a pushpoint sampler on the lake will allow better definition of the plume boundary.

References

Coots, R., 2005. Investigation of Petroleum Products in Black Lake Sediment and Surface Water Adjacent to an Underground Storage Tank Site. Washington State Department of Ecology, Olympia, WA. Publication 05-03-030. https://apps.ecology.wa.gov/publications/SummaryPages/0503030.html

Dames and Moore, 1990. Addendum Report of Geotechnical Services, Black Lake Boulevard Expansion for Thurston County Department of Public Works, Thurston County, Washington, Job No. 8538-003-016. Prepared by Dames and Moore, Seattle, WA.

Ecology, 2002. Cleanup Action Plan, Black Lake Grocery, Olympia, Washington. Washington State Department of Ecology, Olympia, WA. Agreed Order No. DE 02TCPSR-3902, Exhibit – A. http://ecyaptcp/DSARS/docViewer.ashx?did=57296

Marti, P., 2011. Quality Assurance Project Plan: Black Lake Grocery Groundwater Confirmational Monitoring. Washington State Department of Ecology, Olympia, WA. Publication 11-03-114. https://apps.ecology.wa.gov/publications/SummaryPages/1103114.html

Marti, P., 2013. Black Lake Grocery Groundwater Confirmational Monitoring, August 2011 to May 2012. Washington State Department of Ecology, Olympia, WA. Publication 13-03-008. https://apps.ecology.wa.gov/publications/SummaryPages/1303008.html

Marti, P., 2014. Black Lake Grocery Groundwater Monitoring Results, November 2013 and May 2014: Data Summary Report. Washington State Department of Ecology, Olympia, WA. Publication 14-03-048. https://apps.ecology.wa.gov/publications/SummaryPages/1403048.html

Marti, P., 2020. Standard operating procedure for purging and sampling monitoring wells plus guidance on collecting samples for volatiles and other organic compounds. Washington

State Department of Ecology, Environmental Assessment Program, SOP EAP078, Version 2.2.
www.ecy.wa.gov/programs/eap/quality.html

Summit, 2000. Final Remedial Investigation and Feasibility Study, Black Lake Grocery, Olympia, Washington. Prepared by Summit Envirosolutions, Inc. for Man K. Pak. August 2000.

Summit, 2004. Compliance Monitoring Report, Black Lake Grocery, Olympia, Washington. Project Number 0551-002. Prepared by Summit Envirosolutions, Inc. for Man K. Pak. July 2004.

Summit, 2005. Engineering Design Report, Black Lake Grocery, Olympia, Washington. Project Number 0551-002. Prepared by Summit Envirosolutions, Inc. for Man K. Pak. March 2005.

WAC 173-340-720. Groundwater Cleanup Standards. Washington State Department of Ecology, Olympia, WA.

WAC 173-340-740. Unrestricted Land Use Soil Cleanup Standards. Washington State Department of Ecology, Olympia, WA.

Appendix. Sampling Results, 1993-2021

This appendix presents sampling data from Black Lake Grocery monitoring wells from 1993 through 2021.

The following qualifiers, symbols, and abbreviations are used in the tables below:

- **Bold**: Analyte was detected.
- **Underline**: Values are greater than the CAP cleanup levels.
- U: Analyte was not detected at or above the reported value.
- REJ: Sample results rejected, the presence or absence of the analyte cannot be verified.
- --: Not Sampled
- CAP CL: Cleanup Action Plan Cleanup Limit.

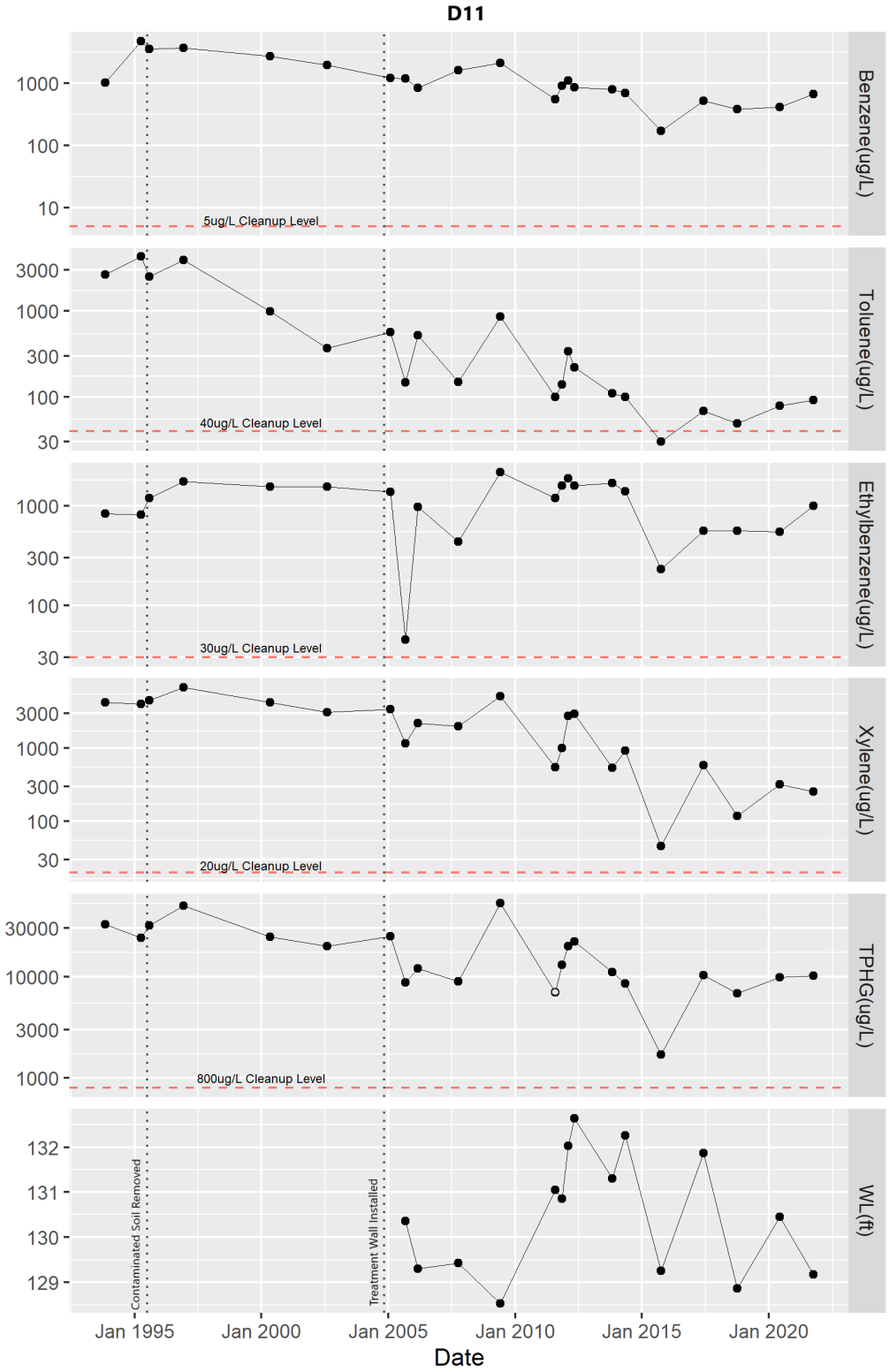

Figure A1. Contaminant concentrations (µg/L, log scale) and groundwater elevations (ft) for well D11, November 1993 to October 2021. Open circles indicate analyte was not detected and are plotted at one-half the reporting limit.

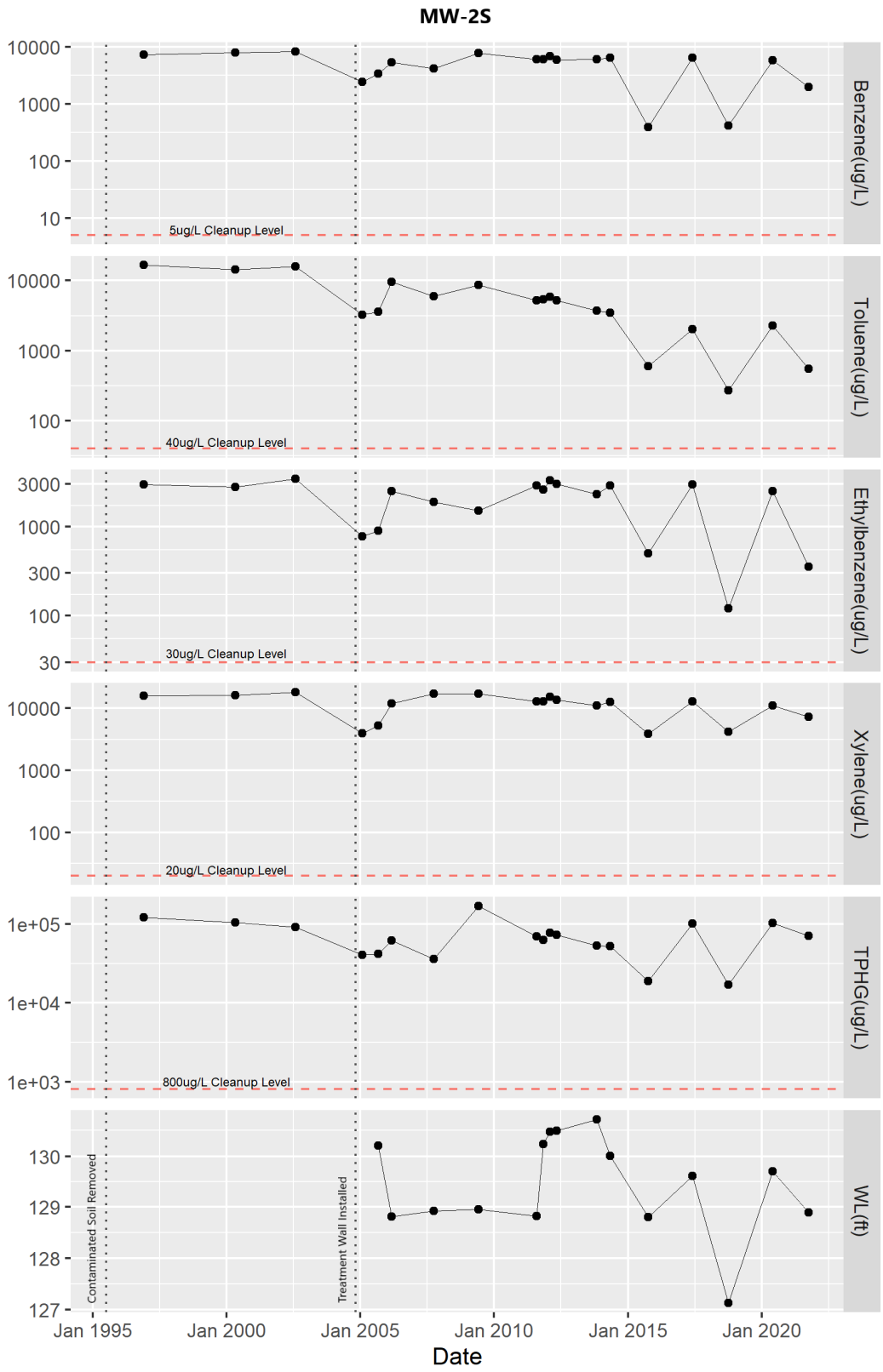

Figure A2. Contaminant concentrations (µg/L, log scale) and groundwater elevations (ft) for well MW-2S, November 1993 to October 2021.

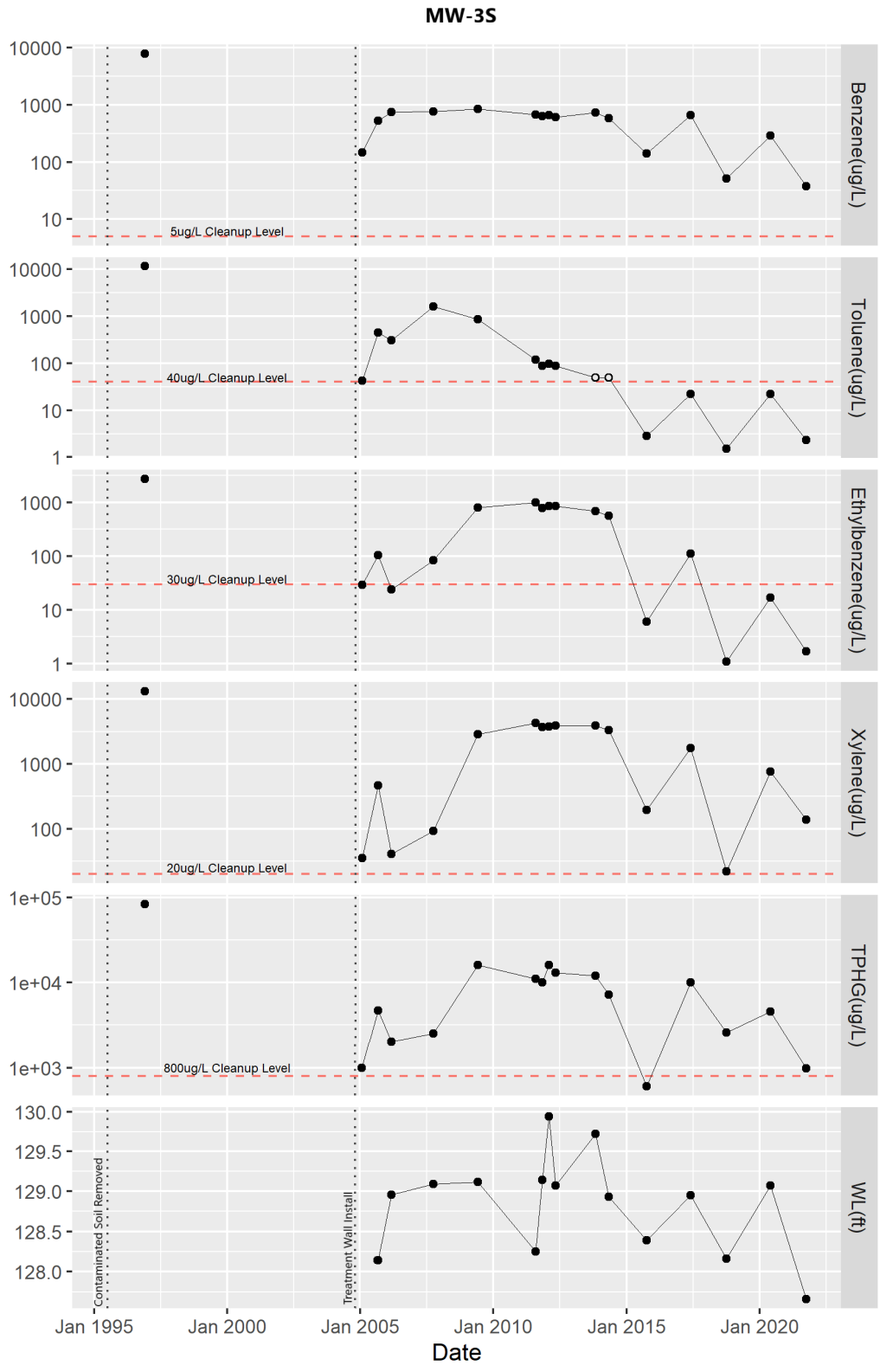

Figure A3. Contaminant concentrations (µg/L, log scale) and groundwater elevations (ft) for well MW-3S, November 1993 to October 2021. Open circles indicate analyte was not detected and are plotted at one-half the reporting limit.

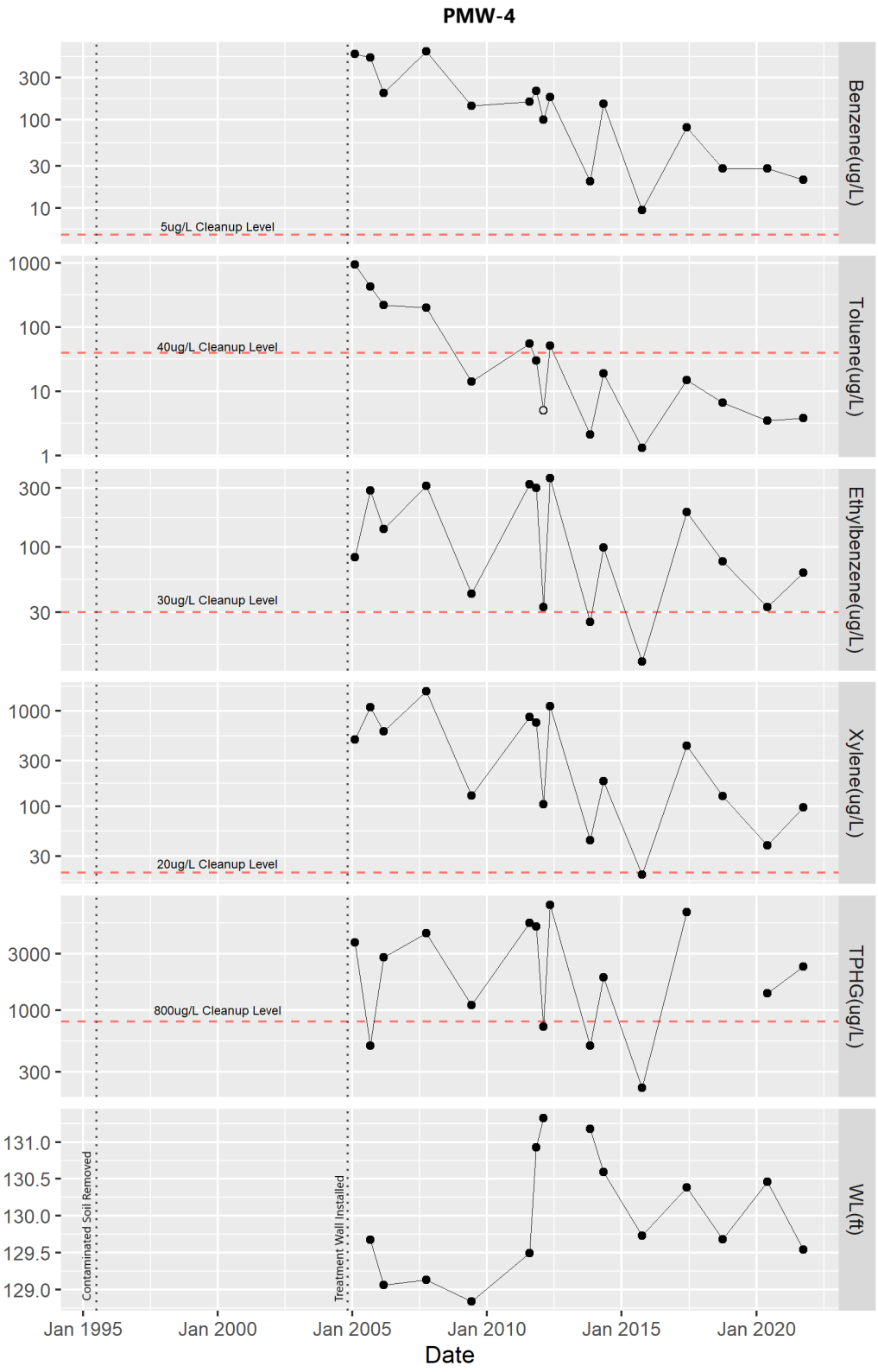

Figure A4. Contaminant concentrations (µg/L, log scale) and groundwater elevations (ft) for well PMW-4, November 1993 to October 2021. Open circles indicate analyte was not detected and are plotted at one-half the reporting limit.

Table A1. Analytical results from 1993 to 2014 for monitoring well D9.

Date	Benzene	Toluene	Ethylbenzene	Total Xylene	TPH-G
Nov-93	**909**	**3520**	**1720**	**6050**	**57,570**
Apr-95	**830**	**1500**	**1300**	**2600**	**28,000**
Aug-95	**570**	**680**	**510**	**1100**	**13,000**
Dec-96	**164**	**190**	**170**	**418**	**3300**
May-00	--	--	--	--	--
Aug-02	--	--	--	--	--
Feb-05	1 U	**8.4**	**4.9**	**33**	**1510**
Sep-05	1 U	**17**	**3.7**	**18**	**160**
Mar-06	1 U	1 U	1 U	1 U	100 U
Oct-07	1 U	1 U	1 U	1 U	100 U
Sep-09	1 U	1 U	1 U	1 U	100 U
Aug-11	1 U	1 U	1 U	3 U	140 U
Nov-11	1 U	1 U	1 U	3 U	40 U
Feb-12	1 U	1 U	1 U	3 U	70 U
May-12	1 U	1 U	1 U	3 U	70 U
Nov-13	1 U	1 U	1 U	3 U	70 U
May-14	1 U	1 U	1 U	3 U	70 U
CAP CL	**5**	**40**	**30**	**20**	**800**

Table A2. Analytical results from 1993 to 2013 for monitoring well D10.

Date	Benzene	Toluene	Ethylbenzene	Total Xylene	TPH-G
Nov-93	**8450**	**8670**	**1450**	**5260**	**30,680**
Apr-95	--	--	--	--	--
Aug-95	--	--	--	--	--
Dec-96	**8150**	**4830**	**2190**	**9680**	**45,500**
May-00	**5580**	**931**	**1070**	**3660**	**40,700**
Aug-02	**8270**	**674**	**1680**	**3290**	**32,100**
Feb-05	**706**	**79**	**237**	**295**	**5420**
Sep-05	**3440**	**368**	**525**	**1050**	**15,700**
Mar-06	**4000**	**150**	**570**	**290**	**9000**
Oct-07	**510**	**22**	**38**	**190**	**1300**
Sep-09	**3700**	**130**	**540**	**290**	**6800**
Aug-11	**4400**	**120**	**700**	**400**	**3300**
Nov-11	**2700**	100 U	**360**	300 U	**2300**
Feb-12	**5800**	100 U	**910**	**750**	**4700**
May-12	**2000**	**58**	**410**	**450**	**2500**
Nov-13	REJ	REJ	REJ	REJ	REJ
CAP CL	**5**	**40**	**30**	**20**	**800**

Table A3. Analytical results from 1993 to 2021 for monitoring well D11.

Date	Benzene	Toluene	Ethylbenzene	Total Xylene	TPH-G
Nov-93	1020	2670	838	4180	32750
Apr-95	4700	4300	820	4000	24000
Aug-95	3500	2500	1200	4500	32000
Dec-96	3640	3950	1770	6740	49800
May-00	2690	988	1570	4220	24500
Aug-02	1950	370	1570	3090	19900
Feb-05	1200	570	1390	3420	25000
Sep-05	1170	148	45	1170	8710
Mar-06	830	520	980	2200	12000
Oct-07	1600	150	440	2000	8900
Sep-09	2100	860	2200	5100	53000
Aug-11	550	100	1200	550	14000U
Nov-11	900	140	1600	1000	13000
Feb-12	1100	340	1900	2760	20000
May-12	850	220	1600	2940	22000
Nov-13	790	110	1700	540	11000
May-14	690	100	1400	930	8500
Oct-15	170	30	230	46	1700
Jun-17	516	68	564	585	10300
Oct-18	382	49	566	119	6800
Jun-20	413	79	547	320J	9780
Oct-21	663	92	1000	256	10200
CAP CL	5	40	30	20	800

Table A4. Analytical results from 1995 to 2014 for monitoring well D12.

Date	Benzene	Toluene	Ethylbenzene	Total Xylene	TPH-G
Aug-95	**0.5**	0.5 U	**0.7**	1 U	50 U
Dec-96	0.5 U	0.5 U	0.5 U	1 U	50 U
May-00	0.5 U	0.5 U	0.5 U	1 U	50 U
Aug-02	0.5 U	2 U	1 U	1.5 U	100 U
Feb-05	**17**	**34**	**5.8**	**31**	**360**
Sep-05	**2.2**	**1.4**	1 U	**2**	100 U
Mar-06	**1.6**	1 U	1 U	**15**	100 U
Oct-07	**9.6**	1 U	1 U	**24**	**140**
Sep-09	1 U	1 U	1 U	3 U	100 U
Aug-11	1 U	1 U	1 U	3 U	140 U
Nov-11	1 U	1 U	1 U	3 U	40 U
Feb-12	1 U	1 U	1 U	3 U	70 U
May-12	1 U	1 U	1 U	3 U	70 U
Nov-13	1 U	1 U	1 U	3 U	70 U
May-14	1 U	1 U	1 U	3 U	70 U
CAP CL	**5**	**40**	**30**	**20**	**800**

Table A5. Analytical results from 2005 to 2014 for monitoring well PMW-1.

Date	Benzene	Toluene	Ethylbenzene	Total Xylene	TPH-G
Feb-05	1 U	1 U	1 U	1 U	100 U
Sep-05	**272**	**7.2**	**2.3**	**11**	100 U
Mar-06	1 U	**6.7**	1 U	1 U	100 U
Oct-07	1 U	1 U	1 U	1 U	100 U
Sep-09	1 U	**2.4**	1 U	3 U	100 U
Aug-11	1 U	1 U	1 U	3 U	140 U
Nov-11	**2.5**	**6.6**	**4.2**	**9.4**	**110**
Feb-12	**1.9**	**18**	**2.3**	**5.3**	**92**
May-12	**1.3**	**9.5**	**4**	**7.2**	**83**
Nov-13	**1.6**	**1.1**	**1.1**	**8.9**	70 U
May-14	**3.6**	**1.1**	**1.8**	**16**	70 U
CAP CL	**5**	**40**	**30**	**20**	**800**

Table A6. Analytical results from 2005 to 2014 for monitoring well PMW-3.

Date	Benzene	Toluene	Ethylbenzene	Total Xylene	TPH-G
Feb-05	1.1	8.7	1 U	1 U	125
Sep-05	14	296	9.7	33	523
Mar-06	2.7	320	1 U	16	480
Oct-07	6.1	340	27	34	480
Sep-09	1 U	1 U	1 U	3 U	150
Aug-11	1 U	1 U	1 U	3 U	140 U
Nov-11	1 U	5.4	1 U	3 U	40 U
Feb-12	1 U	1 U	1 U	3 U	70 U
May-12	1 U	1.5	1 U	3 U	70 U
Nov-13	1 U	1 U	1 U	3 U	70 U
May-14	1 U	1 U	1 U	3 U	70 U
CAP CL	5	40	30	20	800

Table A7. Analytical results from 2005 to 2021 for monitoring well PMW-4.

Date	Benzene	Toluene	Ethylbenzene	Total Xylene	TPH-G
Feb-05	550	940	83	500	3750
Sep-05	503	428	287	1090	503
Mar-06	200	220	140	610	2800
Oct-07	590	200	310	1600	4500
Sep-09	144	14	42	130	1100
Aug-11	160	55	320	860	5500
Nov-11	210	30	300	750	5100
Feb-12	100	10U	33	104	730
May-12	180	51	360	1120	7800
Nov-13	20	2.1	25	44	500
May-14	150	19	99	184	1900
Oct-15	9.5J	1.3	16J	19.1J	220
Jun-17	82	15	191	432	6720
Oct-18	28	6.6	77	128	REJ
Jun-20	28	3.5J	33	39	1390
Oct-21	21J	3.8J	62J	97J	2340J
CAP CL	5	40	30	20	800

Table A8. Analytical results from 1996 to 2021 for monitoring well MW-2S.

Date	Benzene	Toluene	Ethylbenzene	Total Xylene	TPH-G
Dec-96	7360	16600	2960	16000	122000
May-00	7930	14300	2780	16300	104000
Aug-02	8270	15800	3450	18100	91800
Feb-05	2430	3220	771	3930	40700
Sep-05	3420	3600	904	5300	41900
Mar-06	5300	9500	2500	12000	62000
Oct-07	4200	6000	1900	17000	36000
Sep-09	7800	8600	1500	17000	170000
Aug-11	6100	5200	2900	13000	70000
Nov-11	6000	5400	2600	12900	63000
Feb-12	6900	5900	3300	15400	77000
May-12	5900	5200	3000	13700	73000
Nov-13	6000	3700	2300	11000	53000
May-14	6400	3500	2900	12700	52000
Oct-15	390	600	500	3900	19000
Jun-17	6480	2040	2980	12930	102000
Oct-18	416J	271J	120J	4220J	16900J
Jun-20	5860	2260	2500	10980	103000
Oct-21	1990J	551J	356J	7280J	71100J
CAP CL	5	40	30	20	800

Table A9. Analytical results from 1996 to 2021 for monitoring well MW-2D.

Date	Benzene	Toluene	Ethylbenzene	Total Xylene	TPH-G
Dec-96	**3040**	**7300**	**1830**	**10,700**	**64,000**
May-00	**787**	**29**	**42**	**13**	**425**
Aug-02	**4.2**	2 U	1 U	1.5 U	**219**
Feb-05	**47**	**105**	**23**	**139**	**1200**
Sep-05	**63**	**21**	**3.7**	**31**	**395**
Mar-06	--	--	--	--	--
Oct-07	--	--	--	--	--
Sep-09	**3.5**	1 U	1 U	3 U	100000 U
Aug-11	1 U	1 U	1 U	3 U	140000 U
Nov-11	**19**	1 U	1 U	3 U	40000 U
Feb-12	**50**	1 U	1 U	3 U	70000 U
May-12	**30**	1 U	1 U	3 U	70000 U
Nov-13	**36**	1 U	1 U	3 U	70000 U
May-14	1 U	1 U	1 U	3 U	70000 U
Oct-15	1 U	1 U	1 U	3 U	70000 U
Jun-17	1 U	1 U	1 U	3 U	70000 U
Oct-18	1 U	1 U	1 U	3 U	70000 U
Jun-20	1 U	1 U	1 U	3 U	70000 U
Oct-21	1 U	1 U	1 U	3 U	70000 U
CAP CL	**5**	**40**	**30**	**20**	**800**

Table A10. Analytical results from 1996 to 2021 for monitoring well MW-3S.

Date	Benzene	Toluene	Ethylbenzene	Total Xylene	TPH-G
Dec-96	7860	11600	2730	13200	83600
May-00	--	--	--	--	--
Aug-02	--	--	--	--	--
Feb-05	147	43	29	35	1000
Sep-05	532	448	105	465	4700
Mar-06	750	310	24	41	2000
Oct-07	760	1600	84	92	2500
Sep-09	840	860	790	2900	16000
Aug-11	680	120	1000	4300	11000
Nov-11	640	87	780	3700	10000
Feb-12	660	97	860	3800	16000
May-12	610	88	860	3900	13000
Nov-13	730	100U	680	3950	12000
May-14	590	100U	560	3310	7200
Oct-15	140	2.8	6	195	600
Jun-17	667	22	112	1753	9980
Oct-18	51	1.5	1.1	22	2580
Jun-20	293	22	17	759J	4530
Oct-21	38	2.3	1.7	137	984
CAP CL	5	40	30	20	800

Table A11. Analytical results from 1996 to 2009 for monitoring well MW-3D.

Date	Benzene	Toluene	Ethylbenzene	Total Xylene	TPH-G
Dec-96	132	138	21	1440	11,600
May-00	--	--	--	--	--
Aug-02	0.5 U	2 U	1 U	1.5 U	100 U
Feb-05	1 U	1 U	1 U	1 U	100 U
Sep-05	78	89	16	100	800
Mar-06	1.6	1 U	1 U	1 U	100 U
Oct-07	51	70	44	190	490
Sep-09	1 U	1.4	1 U	5	100 U
Aug-11	1 U	1 U	1 U	3 U	140 U
Nov-11	1 U	1 U	1 U	3 U	40 U
Feb-12	1 U	1 U	1 U	3 U	70 U
May-12	1 U	1 U	1 U	3 U	70 U
Nov-13	1 U	1 U	1 U	3 U	70 U
May-14	1 U	1 U	1 U	3 U	70 U
CAP CL	5	40	30	20	800